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SECTION OF THE MANLIUS LIMESTONE AT THE NORTHERN END OF THE HELDERBERG PLATEAU

CHARLES S. PROSSER
Ohio State University

The Helderberg Mountains, or more properly plateau, form a prominent topographic feature of eastern New York the northern escarpment of which is very conspicuous to the south when traveling by electric or steam car between Schenectady and Albany.

Stratigraphic geology in America had its beginning in Albany and Schoharie counties, New York, so that for many years the Helderbergs have been classic ground for geologists. Near the northern end, about south of Meadowdale on the Delaware & Hudson railroad, a highway known as the Indian Ladder road climbs the steep escarpment and this section has been visited and studied by many geologists. Several years ago the writer described this section,¹ but at that time the limestones forming the conspicuous cliff were known as the Tentaculite and Pentamerus. It was attempted to separate these two formations according to the original definition of Gebhard and later description of Mather; but since the line of division was not very clearly indicated in the original description perhaps the writer was not altogether successful in locating the line of separation used by those early geologists. After the preparation of my paper, geographic names were substituted for those based upon the generic names of inclosed fossils and Vanuxem's "Manlius water-lime group," shortened to Manlius limestone, replaced the Tentaculite limestone, and the new name of Coeymans limestone was proposed to replace the Pentamerus.² Later, Professor G. D. Harris studied the Helderbergs and published a general section, "based largely on the outcrops near Indian Ladder," together with four special sections.³ Mr. Christopher A. Hartnagel, assistant

¹ *Eighteenth Ann. Rept. State Geologist* [N. Y.], pp. 53-56.

² *Science*, N. S., Vol. X, Dec., 1899, pp. 876, 877.

³ *Bull. Am. Paleontology*, No. 19, 1904, Pl. 1, and pp. 24-26.

geologist of the Geological Survey of New York, also studied the Indian Ladder cliff and sent me a detailed section from the top of the "Hudson River" sandstone to the base of the Coeymans limestone, and recently the writer spent a day in a re-examination of that part of the section. The typical section near Manlius has also been examined and after this study it is apparent that the line of division between the Manlius and Coeymans limestones in the Indian Ladder section ought to be drawn higher than it was in the section published by the writer in his article of 1901. This probable change was indicated by the writer in a footnote on p. 290 of Professor Amadeus W. Grabau's "Guide to the Geology and Paleontology of the Schoharie Valley in eastern New York."¹

The following section is based to some extent on one furnished by Mr. Hartnagel, but it has all been remeasured and verified by the writer and on account of the importance of the Helderberg section in geological literature it is considered worthy of publication.

No.		Thickness of Zone— Feet	Total Thickness— Feet
13.	Bluish-gray, coarser-grained limestone than the subjacent beds which is limited at the base by a rather marked bedding plane. In the lower 1½ feet Mr. Hartnagel reported <i>Strophonella punctulifera</i> (Con.) Hall, <i>Spirifer vanuxemi</i> Hall, and <i>Leperditia alta</i> (Con.) Hall. <i>Gypidula galeata</i> (Dal.) H. and C. appears above the 1½-foot zone and within 5 feet becomes abundant. At the base is a coral resembling <i>Cyathophyllum</i> . The lower 2 feet of this division Professor Harris called "Transition layers," ² and this name for the zone is quite appropriate since, lithologically, the rock is bluish-gray in color and coarser grained than the subjacent Manlius limestone; but on the other hand it contains <i>Spirifer vanuxemi</i> Hall and <i>Leperditia alta</i> (Con.) Hall, which are generally considered as characteristic of the Manlius limestone, while	36+	95+

¹ *New York State Museum, Bull. 92, 1906, 386 pages, 225 figs., 24 pls., and "Geologic Map of the Schoharie and Cobleskill Valleys."* This comprehensive handbook on the geology of the Schoharie valley and northern Helderbergs will prove of inestimable value to students of this classic region.

² *Bull. Am. Pal.*, No. 19, p. 25.

No.		Thickness of Zone— Feet	Total Thickness— Feet
	<i>Gypidula galeata</i> (Dal.) H. and C., the characteristic fossil of the Coeymans limestone, was not noted until just above this zone. In this cliff it is evident that the line of division between the Manlius and Coeymans limestones is not sharply marked. The most clearly marked physical change is at the above-noted bedding plane, where Mr. Hartnagel prefers to draw the line of division between these two formations which, in some respects, appears to be the most satisfactory line of division. In the Indian Ladder highway cut from this bedding plane 36+ feet of Coeymans limestone was measured.		
12.	<i>Manlius limestone</i> .—From this horizon the subjacent rock undoubtedly belongs in the Manlius. At the top is frequently a blue, thin-bedded limestone about 6 in. thick, which contains <i>Leperditia alta</i> (Con.) Hall. The color is dark blue like that of the Tentaculite limestone. This is No. 2 of Professor Harris' section. Below is a Stromatopora bed which, on the cliff some rods to the east of the "ladder," varies in thickness from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet. This is No. 3 of Professor Harris' section which is 3.1 feet in thickness where he measured it, a quarter of a mile west of the "ladder," while in the cut on the highway 4 feet was obtained and <i>Spirifer vanuxemi</i> Hall was noted.	3±	59±
11.	Dark blue, somewhat irregularly bedded limestone, the lower part of which is generally quite massive, but the upper $1\frac{1}{2}$ to 2 feet is thinner bedded and contains <i>Leperditia alta</i> (Con.) Hall. The thickness of this zone varies along the cliff from 5 feet, some distance east of the "ladder," to $5\frac{1}{2}$ feet in Hartnagel's section, 6 feet in Harris', where it is No. 4, and $6\frac{1}{2}$ feet in the highway cut. The most conspicuous lithologic break in this portion of the cliff occurs at the base of this zone; but the color of the rock and its fauna ally it more closely with the Tentaculite than the Pentamerus limestone.	6	56

No.		Thickness of Zone— Feet	Total Thickness— Feet
10.	Cement beds which are compact, even bedded, and generally weathered back a foot or two, and sometimes several feet within the face of the cliff. This zone, as a rule, is conspicuously shown on the face of the escarpment. Its thickness is somewhat variable, ranging from 4 feet, 9 inches, at the first spring east of the highway to 3 feet in Harris' section. It is given as 4½ feet by Hartnagel and on the Indian Ladder road it is 3 feet, 9 inches. In my former paper this zone formed the upper part of what was termed the transitional beds from the Tentaculite to the Pentamerus limestone; but it was included in the Tentaculite limestone. They were termed transitional because <i>Tentaculites gyracanthus</i> Eaton, the characteristic fossil of the Tentaculite limestone, was not found in them, while some of the other Tentaculite fossils were found well toward their top and the marked lithologic break at the top of the cement zone was thought to represent the line of division between these two limestones as used by the older geologists. At the base of the cement rock is generally a shaly limestone, about 6 inches thick, which frequently shows ripple marks. The distance from the top of this zone to the base of the Manlius limestone may be easily measured in the cliff near the first spring east of the Indian Ladder road.	4½±	50—
9.	Massive rough limestone containing Stromatopora in which Mr. Hartnagel reported <i>Spirifer vanuxemi</i> Hall and <i>Leperditia alta</i> (Con.) Hall.	5	45½
8.	Thin-bedded limestone with Stromatopora layer at base. These two zones correspond to No. 6 of Harris' section with the same thickness.	4	40½
7.	Massive compact layer.	3	36½
6.	Thin-bedded, dark-blue limestone which has a metallic ring. Many of the layers contain immense numbers of <i>Tentaculites gyracanthus</i> Eaton.	22½	33½
5.	Thick and thin layers of dark-blue lime-	6½	10½

No.		Thickness of Zone— Feet	Total Thickness— Feet
	stone with a thickness of $6\frac{1}{2}$ feet and perhaps it may reach $7\frac{1}{2}$ feet. A massive layer near the middle of this zone, according to Mr. Hartnagel, contains abundant specimens of <i>Modiolopsis dubius</i> Hall and <i>Lepiditria alta</i> (Con.) Hall while <i>Spirifer vanuxemi</i> Hall is common. The base of this zone marks the bottom of the Manlius limestone with a total thickness of $54\frac{1}{2}$ + feet in the above section.		
4	Soft seam of shaly, much-decomposed material about $\frac{1}{2}$ -inch thick. This layer appears all along the exposure at the first fall and the second spring west of the "ladder." The overlying layers are all regular, so that this one marks a change in deposition and, apparently, a formation line of division.	$\frac{1}{2}$ in.	$4\frac{1}{3}+$
3.	Dark, contorted, seamy limestone with appearance of gypsum rock which, on examination, Mr. Hartnagel reports to be a sandy limestone with some clayey material; but no gypsum. This zone has a variable thickness and is more or less irregular.	10+ in.	$4\frac{1}{3}$
2.	Layer containing much pyrite and many seams of calcite, where pyrite is abundant, weathering to a dirty yellow color. The rock contains frequent cavities, is broken, or has irregular structure.	$3\frac{1}{2}$ ft.	$3\frac{1}{2}$
1.	"Hudson River" sandstone, thickly bedded and very quartzose at top, dark olive-gray color, with pyrite scattered through the rock in small crystals.		

In my former section the rocks corresponding to Nos. 2 and 3 of the above section were referred to the Waterlime (Rondout)¹ which was accepted by Professor Schuchert in his discussion of the same section.² Professor Harris, however, stated that at this locality "there are four or five feet of gypsiferous and pyritiferous shales, resembling in many ways the Salina beds beneath the Cobleskill

¹ *Eighteenth Ann. Rept. State Geol.* [N. Y.], p. 54.

² *Am. Geol.*, Vol. XXXI, 1903, p. 172.

at Howe's Cave."¹ Mr. Hartnagel carefully examined these beds, failed to find gypsum, stated that the association is quite different from that of the pyrite layer (Salina) at Howe's Cave, and concluded that it was more in harmony with known facts to refer these layers (Nos. 2 and 3) to the Rondout.

The Manlius limestone is regarded as beginning with the base of No. 5 and extending at least to the top of No. 12, and perhaps a foot and a half higher, with a total thickness of $54\frac{1}{2}$ + feet. This thickness is $8\frac{1}{2}$ feet greater than the sum of the Tentaculite and transitional beds as given in my paper of 1901, due to the addition of Nos. 11 and 12 of the above section which have a united thickness of about 9 feet. If to the $54\frac{1}{2}$ + feet which I have given as the thickness of the Manlius there be added the overlying transition layer of Harris, which he gives as 2 feet, then the thickness of the Manlius limestone will become $56\frac{1}{2}$ + feet and the measurements of Harris and myself identical in the Indian Ladder cliff.

The thickness of the Pentamerus limestone in the 1901 paper was given as from 49 to 52 feet along the Indian Ladder cliff and subtracting the lower 9 feet, which is now put in the Manlius, there remains between 40 and 43 feet for the Coeymans limestone.

It is also probably true that in the Countryman Hill section by Prosser and Rowe² a similar 9 feet ought to be taken from the base of the Pentamerus limestone and added to that of the Tentaculite to make the total thickness of the Manlius limestone, in accordance with the section of that hill given by Professor Harris.³ The writer has not been able to re-examine this section, but if the above change be made then the thickness of the Manlius limestone in the Prosser and Rowe section will become 55 feet and that of the Coeymans limestone, 41 feet.

¹ *Bull. Am. Pal.* No. 19, p. 25.

² *Seventeenth Ann. Rept. State Geol. [N. Y.]*, 1899 [1900], pp. 329-42.

³ *Bull. Am. Pal.*, No. 19, p. 26.